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ABSTRACT

This discussion focuses on the transition from an industrial society to an information society, and on the changing nature of work life as a result of new technologies. An examination of the changing workforce (new occupations and skills based upon technology) results in a listing of emerging jobs and occupations which illustrate the increasing importance of technology. Technological literacy is identified as a matter for critical concern in an information society. Technological literacy is seen as encompassing all of the literacies--basic skills, scientific, and computer, as well as the humanities and the social sciences--with a broader view of technology incorporating the various information technologies. Also discussed are new essential skills which focus on process rather than subject matter content, and include critical thinking, problem solving, creativity, application, synthesis, decision making, communication, and evaluation and analysis. Implications of these societal changes for educators are discussed and include consideration of possible changes in the public school curriculum as well as in teacher education. (JD)

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THE CHALLENGE:
DEVELOPING TECHNOLOGICAL LITERACY IN EDUCATION

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The Challenge: Developing Technological Literacy in Education

We certainly cannot say that opinions are lacking on the status of education provided through schools and higher education. It seems clear, among other things, that education, public education in particular, is not addressing the needs of our technological/information society. During the last year we have been inundated with reports critical of education beginning with Mortimer Adler's Paidiea Proposal which came out late last summer. Others since then include: (1) A Nation at Risk, by the National Commission on Excellence; (2) The Report of the Task Force on Federal Elementary and Secondary Education Policy, by the Twentieth Century Fund; (3) The Report of the National Task Force on Education for Economic Growth, the Education Commission of the States (being published in June 1983); (4) Academic Preparation for College: What Students Need to Know and Be Able To Do, the College Board; (5) Investing in America's Future: The Role of Public Education in Economic Growth, National Education Association; and (6) The Study on Schooling, John Goodlad (A Place Called School, being published this summer).

What strikes me about this myriad of reports is the underlying assumption that education contributes to economic growth--that's good. And I believe it does. What concerns me most is that no new solutions are being proposed. Recommendations are essentially the same old remedies, only more of them. Disregarded has been the need to acknowledge that we may indeed be teaching the wrong things the wrong way. What is not given appropriate attention is the primary function of education today--providing individuals with the skills and attitudes to adapt to change. To better understand the dynamics affecting the current education

maelstrom, this discussion addresses three: (1) our society in transition, (2) the changing nature of work, and (3) the impact of technology on education. Their influence on public education implies the need for dramatic change in how we educators approach the complex challenges before us.

Society in Transition

While the revolution from an agricultural to an industrial society took 100 years, the present restructuring from an industrial society to an information society has taken only 20. The rapidity with which this second revolution has occurred has made adaptation to social changes difficult. Indeed, it appears that the American economy has changed before its thinking has. We are well aware that the information revolution is occurring; we are in a post-industrial society; and blue-collar work as well as some white collar work is being replaced by knowledge technology. The revolution is having major influence on dramatic changes taking place in the workforce.

An April, 1982 Census Bureau report confirmed the fact that the Nation has moved from a production-based economy to a service-based economy. A conclusion based on the fact that only 20% of U.S. workers are now involved with the manufacturing of products, while 65% are providing informational services. The most essential resources identified in this service-based economy is educated people. Therefore, high unemployment of unskilled and semi-skilled workers is inevitable as our information society expands.

The economy is changing from one of perpetual expansion to one of equilibrium. The evolving equilibrium economy is characterized by shortened work hours, redistribution of work assignments, and great

expansion of services. With the perpetual demand for individuals to learn and use new information and skills, education provides the key.

Knowledge Workers. With our Nation's shift to an equilibrium economy, job growth has moved increasingly to what we have termed "knowledge workers". Their jobs are of greater diversity, interest, and challenge, with information occupations encompassing lawyers, teachers, engineers, computer programmers, systems analysts, secretaries, technicians, social workers, doctors, nurses, librarians, the list goes on.

What is a "knowledge worker"? According to a recent special report in Business Week, there are three basic classifications of knowledge workers: senior managers, other managers, and professionals.[1] They are primarily involved with five categories of work tasks.

Figure 1

WORK OF THE KNOWLEDGE WORKER	
Task	Activities
1. Less Productive	waiting idle, organizing work, scheduling, seeking a person, seeking information, expediting, filing, copying, transcribing, etc.
2. Meetings	listening, talking, discussing, observing
3. Document Creating	composing, dictating, editing, and drawing/designing
4. Analyzing	analyzing and calculating
5. Reading	annotating/routing and reading

In all three categories of managers, the major amount of work effort is spent performing task one, Less Productive Activities, and task

two, Meeting Activities. The least amount of work time, less than 10%, is spent Reading.

A Changing Workforce

As to the job outlook for this decade for factory workers the future looks bleak. Many traditional manufacturing jobs will be lost to automation. Younger workers without seniority will never be called back. In the 1980s, jobs programs will be needed for people with good employment records, but with the wrong skills. In the industrial heartland of the United States (Michigan, Ohio, Indiana, Illinois, Wisconsin) 970,000 more jobs will be lost.

For women the outlook is brighter. In April, the U.S. Department of Labor reported that two-thirds of newly hired workers were women--most employed in the service industries. Very likely the average woman will have a better chance of finding a job than the average man.

High school graduates will also have better opportunities, especially as skilled workers. It is a myth that a high tech society needs more college graduates. What it needs are more technically trained workers, and high school graduates with good oral and written communication skills, along with basic training in computers, word processors will be in great demand. The skilled worker of the 1980s will work in an office or a laboratory, not in a factory.

College graduates will not fare as well. Already there are fewer job opportunities and starting salaries are lower. Those who are technically trained--engineers, computer scientists--will command the larger starting salaries. Technically trained high school graduates are likely to earn more than college graduates with non-technical training (humanities, teaching, etc.). Nonetheless, it still pays to get a college

education, since college trained workers do not suffer as high a jobless rate as other workers. There also will be a significant reduction of middle management as automation further permeates the workplace.

During this decade job choices are likely to be slimmer; more people will be settling for different jobs than they expected; and pay is likely to be lower.

Occupational Forecast. Now let's take a look at some of the emerging jobs, as well as those of greatest demand. By the 1990s, millions of new jobs are expected to be available.[2] (See Figure 2)

Figure 2

NEW OCCUPATIONS FORECAST FOR THE 1990s

Occupation	Available Jobs
Industrial Laser Process Technician	2,500,000
Battery Technician	2,500,000
Housing Rehabilitation Technician	1,750,000
Industrial Robot Production Technician	1,500,000
Energy Technician	1,500,000
Hazardous Waste Management Technician	1,500,000
Paramedic	1,300,000
Geriatric Social Worker	1,000,000
Materials Utilization Technician	500,000
Holographic Inspection Specialist	200,000
Bionic-Electronic Technician	200,000
Genetic Engineering Technician	150,000
Total Jobs Forecast	14,500,000

Other emerging job markets and careers include:

-Telecommunications Consultants
-Alternative Telephone Technologies Consultants
-Office Networking Technologists
-Robot Marketing
-Urban Security Force
-Copyright Law Analysts and Aides
-Computer Graphics Designers and Engineers

-Data Bank Managers
-Bionics
-Tele- and Cable-Shopping Installers
-Solar Array Technicians

There is much promise if these occupations actually appear, especially in the numbers forecast. However, the nature of these occupations makes very evident this is not an unskilled or semi-skilled work force we are talking about. Some other figures provided by the U.S. Bureau of Labor Statistics provide a picture of the most rapidly growing occupations and the largest number of new jobs covering the period from 1978 to 1990. (See Figures 3 and 4)

Figure 3

MOST RAPIDLY GROWING OCCUPATIONS

Occupation	% Growth in Employment 1978-1990	Number of New Jobs by 1990
All Occupations	22.5	21,980,000
Data Processing Machine Mechanics	147.6	96,572
Paralegal Personnel	132.4	39,310
Computer Systems Analysts	107.8	203,357
Computer Operators	87.9	151,000
Office Machine and Cash Register Servicers	80.8	40,666
Computer Programmers	73.6	153,051
Aero-Astronautic Engineers	70.4	41,315
Food Preparation and Service Workers, Fast Food Restaurants	68.8	491,900
Employment Interviewers	66.6	35,179
Tax Preparers	64.5	19,997

Source: Bureau of Labor Statistics

Figure 4

LARGEST NUMBER OF NEW JOBS

Occupation	Growth in Employment in Thousands, 1978 - 1990
Janitors and Sextons	671.2
Nurses' Aides and Orderlies	594.0
Sales Clerks	590.7
Cashiers	545.5
Waiters/Waitresses	531.9
General Clerks, Office	529.8
Professional Nurses	515.8
Food Preparation and Service Workers, Fast Food Restaurants	491.9
Secretaries	487.8
Truckdrivers	437.6

Source: Bureau of Labor Statistics

Other Expectations. More about what the future might hold--by the year 2000, as automation takes hold, the factory assembly line will be a thing of the past. In the United States, big business will grow even larger, dominating the markets of the new technologies and services. General Motors will make small, fuel-cell powered cars for local travel and buses for mass transit in congested urban areas. While GM will remain profitable for many years, by the year 2010 it could vanish from the leading ranks of corporate conglomerations.[3]

Population changes taking place also will have a dramatic impact on the workforce of our information society. As we approach the twenty-first century we can anticipate: (1) a dramatic increase in the median age of Americans, (2) a precipitous decline in the number of teenagers, (3) a dramatic increase in those over age 65, and (4) a shrinking college age population. The U.S. population now 232 million, will expand by less

than 1% to the year 2000 with growth possibly ceasing and peaking at 309 million by 2050. For the American workforce, these population changes will result in fewer young workers, more middle-aged workers, and a declining number of workers overall. Further, these trends suggest that unemployment will subside as a persistent problem. We simply will not have available today's number of workers. Enrollments in secondary schools and colleges will decline. And productivity as a result of automation, and subsequently competition of U.S. businesses will escalate.

What else might we anticipate as a result of the new technologies? We can anticipate that the need for workers will dwindle as machines take over more and more of the work of humans. There will be a restructuring of the work week, which might be reduced from five days to four to accommodate the reduced need for workers. Such a change has not occurred in almost a century. There will be an adjustment in compensation for work. Hourly wage is likely to be eliminated and replaced by salaried compensation. High tech jobs can be expected to increase by 50% by the end of this decade. The government will take measures to address the social impact of the high technologies, which so far it has grossly underestimated. The manufacturing industries will become increasingly service oriented. The information/service economy will become even more highly skilled and filled with knowledge workers. The role of education in preparing the workers of the future and keeping the knowledge and skills of the current workforce up-to-date will expand dramatically.

Technology and Education

What is the influence of technology on the individual and society? Looking at the social context, four areas of individual human interaction can be identified--family life, learning life, work life, and leisure

life. The focus of this discussion is on the transition from an industrial society to an information society, and on the changing nature of work life as a result of the new technologies. Now let's take a look at the most critical social dynamic having major impact on us and our evolving information society--education.

The OTA Report. In November 1982, the Office of Technology Assessment of the U.S. Congress released its report, Informational Technology and Its Impact on American Education.[4] The report addresses the dilemma facing American education in its efforts to respond to the information revolution that is taking place. It identifies the following information technologies: cable, satellite communication, digital telephone networks, broadcast technologies, computers, storage technologies, video technologies, video disks, information services such as videotex and teletext, electronic conferencing, and information networks. Among its findings are the following. (1) The growing use of the information technologies is creating new demands for education and training in the United States. (2) The potential for economic and social penalty for not responding to those demands is increasing. (3) The information revolution is creating new stresses on many societal institutions, public schools in particular. (4) Information technology is already playing an important role in providing education and training in certain sectors. (5) Information technology holds great promise for responding to our society's education and training needs, and it is likely to become a major vehicle for doing so within the next 20 to 30 years.

Among the social changes resulting from the new information technologies, a number of significant developments are having a profound effect on our education system.[5] Those developments include:

1. an increase in the level of education individuals need to participate effectively in society

2. an extension of the period of time during which individuals can and need to be educated

3. an increase in the diversity of educational clientele and thus an increasing diversity in the demand for education

4. a decline in public resources for education, resulting in part from

   -an increase in the cost of producing education
   -a questioning of public benefits associated with education
   -a loss of confidence in institutions providing education

5. the emergence of new institutions that under new circumstances find it profitable to market education

6. the development of new information technologies that allow educational institutions to provide specialized services to specific sectors of the market

In keeping with the other reports mentioned earlier, the future of the American public school system is not viewed optimistically. As to the application of information technology in education and training, we are cautioned its premature and over-zealous use, pointing out: (1) we do not know enough about the educational and psychological effects of technological approaches to instruction; (2) we do not know enough to determine how the new technologies can best benefit the learner; (3) we do not know enough to predict the possible negative effects of its use. Great care must be taken in introducing these new technologies into education.

Challenges Facing Public Education

For the high tech industry, the preparation and training of its knowledge workers has focused on postsecondary education provided by higher education. However, the most essential dimension of education--schooling, kindergarten through grade twelve--has been given inadequate

attention. Schools provide the basic preparation for our workers of the future and should be cultivating a workforce responsive to our rapidly advancing technological society. Unfortunately, this does not seem to be happening. Rather than narrowing, the gap between education and technology continues to grow.

According to Robert Reich, author of The Next American Frontier,

> ...At best, the current system of education prepares young people for preexisting jobs in high-volume, standardized production. Some students are sorted into professional ranks and trained in the manipulation of abstract symbols. Others are prepared for lower-level routine tasks in production sales. Few students are taught how to work collaboratively to solve novel real-world problems--the essence of flexible system production.
>
> U.S. education has been modeled on scientific management. Students are sorted, programmed, and controlled in a high-volume, standardized production process essentially like any other. Knowledge is divided and subdivided into discrete units, delivered according to preset instructions, and monitored at regular intervals through standardized examinations....Students move through high schools and universities as if they were on a conveyor belt.
>
> American education has followed the form of American business. As businesses have merged and consolidated, so too, have schools and universities....increasingly America's educational curriculum is planned and monitored by professional administrators and delivered by teachers whose low salaries and tedious, repetitive jobs are coming to resemble those of production workers in a traditional American factory.[6]

Today's schools are faced with two critical questions: What are appropriate goals for education in the twenty-first century? and, What do students entering a knowledge-intensive era need to learn? As schools strive to become technologically relevant, all sorts of challenges arise. The reexamination and redesign of preservice teacher education, teacher certification, and the evaluation of student performance appear to be inevitable. In addition to the myriad of economic problems public schools

are facing, educators are confronted with other critical issues brought on by the information revolution. Among them--introducing more technology into education, changing traditional delivery systems, and entering into new arrangements with business/industry and government. The issues are complex ones relating to our society in transition which is further highlighting the interrelatedness of technology, employment, and education.

The New Basics. While the traditional basics of reading, writing, and computation are being pursued with great vigor, and indeed are more necessary than ever, a reality we face is that even if all pupils are achieving to the fifth grade skill level, that level of achievement is insufficient for entry level employment in knowledge occupations. While computer literacy is rapidly emerging as a new basic skill, the need for a new set of essential skills, in addition to the basic skills, is becoming increasingly evident. The new essential skills focus on process rather than subject matter content. They include: (1) critical thinking, (2) problem solving, (3) creativity, (4) application, (5) synthesis, (6) decision-making, (7) communication, and (8) evaluation and analysis--skills essential for functioning in a knowledge society. We assume that these skills are being learned, but that learning is not addressed with the intentionality given subject matter content.

Another concern is the renewed emphasis on science and mathematics education as the answer to the ills of American education. (The current flurry reminds me of Sputnik revisited.) While the shortage of good math and science teachers is real and needs to be remedied, placing the burden of responsibility for improving the quality of public education on these two areas does not get at the core of the problem. The resistance to viewing technology as a tool, as an enhancement to learning, is a dilemma

which needs resolution. Human-machine interface, recognized by industry, is also one problem we educators face in schools.

Technological Literacy. This leads us to what may be our most critical concern--technological literacy. The assumption is that math, science, and computer know-how constitute the ingredients of technological literacy, when in fact it is something much broader. The definition of literacy changes with society: In agrarian America literacy entailed writing your name, counting change and reading at a minimal level; in urban America it required greater competence in reading, writing, and mathematics; in technological America it requires more--it requires those new essential skills identified earlier. Technological literacy means

> ...The competence required to engage in complex thinking. It entails possession of the appropriate knowledge and skill to access a continuously changing base of information. Knowing how to use machine technology, such as computers, is important because computers help to store and manipulate information. But the focus must ultimately be on engaging critical thought and teaching people how to continue learning.[7]

Our math and science problems are only symptomatic of a larger more fundamental problem--the eroding infrastructure of our public education system.

There seems to be no consensus on what is meant by technological literacy. To get an idea of how it was being interpreted, I conducted an ERIC search comparing three concepts--scientific literacy, computer literacy, and technological literacy. Using the terms only as they appeared in titles, approximately 200 articles were identified. Of those 200, approximately 90 have been reviewed. Evident from the search was what appears to be a pattern of evolution. Articles on scientific literacy were most prevalent in the 1960s and early 70s; on computer

literacy in the 1970s and early 1980s; and on technological literacy, just beginning in the 1980s. Scientific literacy clearly focused on science education, while computer literacy is focusing on computer applications to the general education curriculum, especially reading and mathematics. Technological literacy has yet to be defined, although it seems to encompass all the literacies--the basic skills, scientific, and computer, as well as the humanities and the social sciences--with a broader view of technology incorporating the various emerging information technologies.

James Burke, author and television host of the BBC produced series "Connections", looks at some of the forces that have contributed to change through innovation. He focuses on inventing the future by understanding change and innovation as it has occurred in the past to the present. Burke views attitude as a critical factor and has identified four attitudes surrounding technology and the future effects of the present high rate of change. Those attitudes include the following four considerations:

1. We should give up the present system oriented towards high technology and return to an 'intermediate' technology making use of resources which cannot be depleted. (return to the land)

2. We should assess scientific and technological research strictly according to its worth for society and curtail all other forms of research.

3. We should allow technology to continue to solve the problems as it always has.

4. Technological research and development should be directed towards producing more durable goods and less planned obsolescence

He goes on to say

> Whichever of these alternatives is chosen, the key to success will be the use we make of what is undoubtedly

> the vital commodity of the future: information. It seems inevitable that, unless changes are made in the way information is disseminated, we will soon become a society consisting of two classes: the informed elite, and the rest.[8]

Lifelong Learning. A final concern is that along with the other knowledge workers in our information society, lifelong learning becomes an even more essential ingredient of the work life of educators. Massive and compulsory inservice education will be necessary to maintain technological relevancy in our education enterprise. Faced with increasingly competitive and diverse institutions marketing education for profit, public schools including higher education can anticipate dramatic changes in structure and function. The immediate concern is for educators to become technologically relevant.

Implications for Educators

What does all this mean for those of us involved in schooling? It means a new focus on process rather than on content in what we teach. Machines are fully capable of providing information typically presented in a course.

It means new roles for teachers and teacher educators. Not just interpesonal relations and communications, but redefining teaching and learning in the context of the new essential skills.

It means redesigning the general education curriculum--preservice, inservice, and K-12 education.

It means looking beyond computers, keeping abreast of the other emerging information technologies that will be integrated with the computer--cable, vidiodisc, teletex and videotext, fiber obtics, lasers, etc.

It means upgrading the knowledge and skills of school administrators, superintendents as well as principals.

And let's not forget the general public, especially parents and school board members, need to be much better informed about the implications of the technological society on their children. This means more parent involvement in schooling.

The questions we are now faced with include, How will public education respond? To close the gap between technology and education will schools redefine the basics and the core curriculum? Redesign the general education curriculum? Redirect teacher education? Restructure teacher certification? Undertake universal inservice at all levels? If not, what can public schools do to effectively prepare individuals to function as contributing members of our information society?

Conclusion

Every sector of society is undergoing dramatic change as it moves from one of perpetual growth to one of equilibrium (slow growth or no growth). Some of the changes we can expect--fewer workers will be needed, knowledge workers will dominate, technical training will be more needed then a college degree. Society may become further stratified into two social bands--the haves, those who adapt to the information society; and the have nots, those unable to adapt.

Education at all levels is being challenged as never before. Suddenly we are finding it necessary to compete, as more and more private and proprietary schools challenge public schools; as more and more businesses challenge higher education. Three areas where we need to give attention have been highlighted here.

1. The Process Skills. How are they/can they be taught? What will provide the intentionality for learning them? How can they best be incorporated into the curriculum? How should educators be prepared?
2. Technological Literacy. What is it? What can we do about it? How can it be infused into the general education curriculum? How can educators be prepared?
3. Lifelong Learning. What do educators involved with schools, educators at all levels need in terms of content, process, awareness, exposure? What approaches should be used? How does collaboration fit in? What attitudes need to change/be developed? How can they be?

The information society is demanding a team effort, and a team effort that extends beyond the field of education as now defined. It demands active interaction with the other sectors of our society--government, business and industry, labor, social services, the mass media, and our citizenry at large.

In closing, a thought provoking quote:

> Everyone has a role in technological development. We are either agents of change or instruments of manipulation. The problem here is that it is too easy for most of us, especially as we mature, to fall behind in our knowledge of technological advances. This attitude or lack of commitment to self-education is compounded over time, and we begin to sense that we are falling further behind, such that life appears to advance at an accelerating pace. The system does not wait for us to catch up; it keeps evolving, resulting in either a feeling of control for the educated or feelings of manipulation for the ignorant (i.e., knowledge is power...). We develop as either agents or instruments of technology. There are no innocent bystanders.[9]

The challenge is before us!

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